HHS Public Access

Author manuscript

Vaccine. Author manuscript; available in PMC 2015 November 24.

Published in final edited form as:

Vaccine. 2013 July 2; 31(0 3): C94–C98. doi:10.1016/j.vaccine.2013.05.034.

Critical issues in implementing a national integrated all-vaccine preventable disease surveillance system☆

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Abstract

In 2007, the World Health Organization published the Global Framework for Immunization Monitoring and Surveillance (GFIMS) outlining measures to enhance national surveillance for vaccine preventable diseases (VPDs). The GFIMS emphasized that VPD surveillance should be integrated and placed in a 'unified framework' building upon the strengths of existing surveillance systems to prevent duplication of activities common to all surveillance systems and to minimize human resource and supply expenditures. Unfortunately, there was little experience in actually developing integrated VPD surveillance. We describe the process of developing operational guidance for ministries of health to implement such an integrated surveillance system for multiple VPDs.

Keywords

Surveillance; Vaccine preventable disease; GFIMS

1. Introduction

Surveillance is the foundation of sound public health practice; however, disease surveillance systems are often fragmented and vertical, based on the characteristics of the targeted disease or syndrome, and the characteristics of the existing public health infrastructure. To

☆The findings and conclusions in this report are those of the author and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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Conflict of interest: No authors have reported a conflict of interest.

address the need for surveillance for vaccine preventable diseases (VPDs), in 2007, the World Health Organization published the Global Framework for Immunization Monitoring and Surveillance (GFIMS), which outlines measures that ministries of health may take to enhance national VPD surveillance [1]. The GFIMs emphasizes that VPD surveillance should be integrated and placed in a 'unified framework' that builds upon the strengths of existing surveillance systems rather than being implemented as new disease-specific and vertical systems. The main goal of an integrated VPD (iVPD) surveillance system is to prevent duplication of activities that are common to all surveillance systems and at the same time to minimize human resource and supply expenditures. Global immunization partners viewed the GFIMS as a welcome framework, at a time when multiple new and underutilized vaccines were entering developing world markets. These new products are costly compared with existing Expanded Programme on Immunization vaccines, and their introduction must be prioritized among other health interventions. In addition to providing routine vaccination program monitoring information, iVPD surveillance data may demonstrate disease impact through a streamlined system that minimizes redundancy and is beneficial and efficient. Enhanced integrated surveillance systems could potentially assist in reaching multiple disease surveillance objectives while providing quality data for decision makers at national and international levels. Building these systems upon the existing national communicable disease network will ideally strengthen surveillance for all communicable diseases of public health importance.

Despite the recommendation from the World Health Organization (WHO) and major partners for expansion of VPD surveillance and immunization program monitoring, countries continued to struggle to implement efficient iVPD surveillance systems even after the GFIMS had been developed and widely distributed, as it did not provide operational guidance for implementation. Few countries had experience in iVPD surveillance systems apart from febrile rash illness surveillance to detect measles and rubella in the Americas [2,3]. The most developed VPD surveillance system globally is the acute flaccid paralysis network, a highly sensitive, but vertical, single disease surveillance system for the detection of poliomyelitis [4]. Examples of other stand-alone systems include regional, sub-regional or national surveillance for influenza-like illness, sentinel site surveillance for meningitis in Africa (Pediatric Bacterial Meningitis [PBM] surveillance) [5], sentinel surveillance for invasive bacterial disease in the Americas (Sistema Regional de Vacunas [SIREVA]) [6], and the global rotavirus surveillance network [7]. Thus, while public health experts believed that iVPD surveillance was a more economic and efficient system, little was known about how to develop and implement a practical and relevant iVPD surveillance system, which surveillance components could feasibly be integrated, and what the programmatic and financial benefits of integrating surveillance for multiple VPDs would be.

The GFIMS' call for the development of iVPD surveillance was timely, given the increasing availability of vaccines for diseases caused by Streptococcus *pneumoniae* (pneumococcus), rotavirus, influenza virus, and human papilloma virus (HPV) in the developing world. Furthermore, the increased uptake of underutilized vaccines such as Haemophilus *influenzae* type b (Hib) vaccine and regionally important vaccines such as Japanese Encephalitis (JE) and Yellow Fever (YF) vaccines further highlighted the need for strengthened or new

surveillance to estimate the local burden of disease and monitor the impact of vaccine introduction [8].

New vaccine introduction generally involves significant expense [9]. For example, in addition to the purchase of new vaccines for the routine immunization program, expansion of existing cold chain capacity and enhancement of other vaccine delivery logistics typically require substantial investments. What was less clear; however, was how to develop quality surveillance necessary for diseases targeted by new vaccines, how to link it with existing vertical disease surveillance systems, and how much additional investment will be required for the system. In 2007, immunization experts at the US Centers for Disease Control and Prevention (CDC), WHO Headquarters and the Pan American Health Organization (PAHO) began to discuss the feasibility of integrating surveillance for multiple diseases. Critical issues related to the potential benefits and limitations of integration were addressed, including which diseases were candidates for integration, which surveillance components could feasibly be integrated, and ways to integrate laboratory and data management activities. We present the process that went into developing operational guidance for ministries of health and the lessons learned in consideration of preparing generic guidelines for integrated “all-VPD surveillance” for countries to adapt to their national circumstances. This is the first time that this process has been undertaken for the integration of VPD surveillance, and while we do not present data from an in-country implementation, our experience may be helpful to countries considering embarking on this type of work. This CDC and PAHO collaboration has led to opportunities to pilot the generic protocol in the Americas.

2. Conceptual development of integrated surveillance

At the onset of the process, it was not known how an integrated product for surveillance would be structured or whether it was a realistic goal within a national context. Before identifying the critical issues to be addressed and the requirements for developing an all-VPD surveillance system, it was important to reach consensus about the definition of the word “integration” in the context of VPD surveillance. “Integrate” is defined as “to form, coordinate, or blend into a functioning or unified whole”, or “to unite with something else” [10]. Thus, while integration denotes a process for combining, it does not in itself refer to the impact of such an action, and nothing inherent in the definition suggests a positive or negative outcome. The term “synergy”, on the other hand, refers to the “interaction of discrete agents such that the total effect is greater than the sum of the individual effects” [11]. The “integrated” surveillance system envisioned was one that would result in synergy, with improved efficiency of resource use, and surveillance performance greater than that of the individual single-disease systems, recognizing that a universal fully integrated surveillance system will not fit all diseases, and it is unlikely that one can be fully achieved. This is partially due to fundamental differences in objectives and methods of surveillance for certain diseases, which do not allow a complete integration.

The integration of surveillance for VPDs may be approached in several ways. Our approach focused on the syndromes associated with diseases prevented by vaccines already in the EPI program as well as by vaccines soon to be added. While global or regional surveillance

goals have been established for most of these ‘EPI diseases’, the objectives for surveillance for a particular disease will define the structure of the surveillance system and the type of surveillance conducted (e.g. sentinel or population-based, target age-group, clinical only or lab-based). For some diseases, for example, it may be important to detect every case in order to reach a goal to eradicate or eliminate the etiologic agent, (e.g. polio globally, measles, and rubella in selected Regions); however, for other diseases detection of disease trends is sufficient (e.g. rotavirus gastroenteritis). An alternative approach may be to conduct surveillance for syndromes that can result from both VPDs and non-VPDs. In the case of acute gastroenteritis, this might include testing stool specimens for other common diarrheal pathogens, such as salmonella and shigella. While a stool specimen is needed for laboratory identification of all these pathogens, the disease surveillance goals for each disease may differ, and surveillance may target different populations. For example, the goal of rotavirus surveillance in the context of vaccine introduction is to provide information on vaccine impact, whereas surveillance for salmonella and shigella is primarily targeted at monitoring disease trends and detecting outbreaks and may therefore include a broader target age group. These differing surveillance goals overlap in the population less than five years of age, where the majority of rotavirus disease occurs and which is targeted by the rotavirus vaccination program, however, this group represents only a small subset of the total population that needs to be followed to identify disease caused by the other diarrheal pathogens.

The integrated VPD surveillance protocol focused on clinical syndromes associated with VPDs that already had established global surveillance goals. These syndromes (and the diseases or disease agents that cause them) included acute flaccid paralysis (AFP [polio]), acute fever and rash (AFR [measles, rubella, varicella]), influenza-like illness (ILI [influenza, pertussis]), meningitis (Hib, pneumococcus, meningococcus), Severe Acute Respiratory Infection (SARI [influenza, pertussis, pneumococcus, Hib]), and acute gastroenteritis (AGE [rotavirus]). We did not include certain VPDs of regional importance such as Yellow Fever and focused on the VPDs for which vaccines either are being introduced or are currently in use globally. We recognize that many other pathogens may cause the syndromes under surveillance, but as the focus of the protocol was collection of information about vaccine impact, we elected not to consider non-VPD pathogens. As a first step, immunization partners identified key surveillance system characteristics that were necessary to begin the process of integrating VPD surveillance. We understood that some surveillance systems may not easily be integrated, particularly if different government departments outside the immunization program were responsible for the different VPD surveillance systems. Hence, one critical requirement for a successful iVPD surveillance system is high level government support that can bring together stakeholders from different departments, including epidemiologists, virologists, and other key groups.

We next identified ten major attributes of a VPD surveillance system (Table 1). These include (1) the existence and use of case definitions, (2) a case detection system, (3) a process for case notification, (4) procedures for case investigation, including standardized data variables, (5) data management procedures, including data analysis and information reporting, (6) outbreak response guidelines, (7) laboratory algorithms and standard procedures, (8) final classification procedures, (9) feedback to partners and (10) clear

program management and supervision. We then created a matrix that mapped these surveillance system attributes for each VPD, and grouped individual diseases by syndrome when possible, to facilitate integrated case detection and investigation (Table 2). Through group discussions and analysis, we identified synergies among different disease surveillance system attributes, and used these to determine which attributes within a surveillance system for a given VPD could be combined with those for another VPD.

We further refined the initial matrix and analysis within the context of WHO-recommended regional and country level VPD surveillance activities, based on currently recommended vaccines. We considered as possible sites for implementation of a pilot project to develop an iVPD surveillance system those countries whose VPD surveillance systems included the above-mentioned attributes. Immunization experts from PAHO in Washington, DC wished to identify a country to pilot the integrated system in order to gain practical experience.

2.1. Development of generic protocol for integrated VPD surveillance

We recognized that remodeling established stand-alone systems may be more challenging than merging new systems into an existing VPD disease surveillance infrastructure. For example, data information systems developed for specific VPD surveillance and existing surveillance data information systems may not be compatible with one another, and this may prevent integration of some system components, thereby limiting the integration of information flow and use. In addition, the priorities and funding streams for single and separate disease initiatives may limit the ability to combine activities or purchases required to combine tasks for different syndromes, including purchasing laboratory equipment or hiring personnel. Bearing these constraints in mind, we developed guidelines using an approach to help characterize the structure of an integrated VPD surveillance system, with the understanding that there may be different national, regional, and global objectives. Ideally, a surveillance system should be sufficiently flexible to meet the needs of all administrative levels, taking into consideration global and regional disease elimination (measles, rubella) and eradication (polio) goals, as well as overall disease control and strain monitoring (influenza, Hib, pneumococcus, and rotavirus) goals. We included the VPDs that required laboratory confirmation for case classification, and considered each disease individually in terms of the type of surveillance that was needed, based on national control objectives (e.g. population-based vs. sentinel surveillance), as well as whether surveillance needed to be conducted in hospitals, clinics or in all health-care facilities. We further considered each component of a surveillance structure needed for a particular disease, including the type of case detection required (active or passive), patient volume needed to detect trends for each disease, the type of investigation (aggregate case counts or case-based investigation), type of laboratory specimen and testing needs, and the type (aggregate or individual case/lab data) and frequency (monthly or weekly) of reporting. For instance, in order to identify every measles case and meet elimination goals, every administrative level of the health care system conducts measles surveillance. On the other hand, the aim of rotavirus disease surveillance is identification of a sample of case-patients with the most severe presentations, in order to assess vaccine impact and identify circulating genotypes that are causing disease. The most appropriate structure for this is hospital-based sentinel surveillance for children under age five years hospitalized for treatment of acute diarrhea.

After reviewing the unique surveillance needs of the target diseases, we compared the surveillance objectives for each disease to determine how to integrate new and existing elements within existing systems, keeping in mind the necessary surveillance type, structure, and investigation; the need for laboratory testing; and the type and frequency of reporting.

We selected a surveillance structure that consisted of a combination of population-based and sentinel site surveillance. We grouped diseases by both syndromes and age-groups under surveillance, and then integrated activities or surveillance components for the target diseases when appropriate and feasible. For example, we combined surveillance activities for diseases that shared similar case-finding and investigation procedures, and repeated this process for issues related to laboratory samples, data management, analysis, and feed-back. We developed a generic protocol that included clinical, laboratory, and reporting procedures (Figs. 1 and 2) and surveillance algorithms for national use and adaptation, and identified key variables for case investigation forms and issues to consider in both sentinel site and population-based surveillance forms. The goal was to align the procedures with existing national and regional surveillance guidelines for each disease included.

3. Requirements for pilot project

To identify a country to pilot the surveillance integration, we identified key requirements (Fig. 1). As previously noted, clear interest and agreement by the national ministry of health, with a commitment to sustainability with national funds and only modest donor support was critical. Since the system was to include surveillance for diseases prevented by new vaccines, a pilot country needed to have early adoption of one or more new vaccines as well as existing laboratory capacity. In addition, the national Ministry of Health needed to agree to partner with the private sector as well as with international agencies. Finally, since it would be a pilot project, we requested that the site for the initial implementation of the iVPD surveillance system agree to share lessons learned and economic costing information with the international community. Following discussions with PAHO and with the agreement and interest of the government of Costa Rica, the iVPD surveillance was pilot-tested in Costa Rica.

4. Implementation and the way forward

The next step in the integration process was to implement the protocol at a national level to learn the extent to which the integration could be achieved within an established system. With technical assistance from CDC and PAHO, the Costa Rica Ministry of Health began the implementation process in 2008 [12]. Toscano and colleagues have detailed the incremental costing of the implementation of the project [13], and lessons learned by Costa Rica's experience will provide key information on the practical application and sustainability of an iVPD surveillance system.

This integration process focused on building upon existing measles, rubella, and polio surveillance networks and expanding to include diseases whose vaccines have been prioritized by WHO such as Hib, pneumococcus, and rotavirus. The addition of other diseases, such as influenza and pertussis demonstrated the flexibility that an integrated

surveillance system should possess in order to be able to include additional diseases in the network and then to be adapted to the country or regional priorities.

Ministries of health choosing to implement an integrated all-VPD surveillance system should identify and prioritize attributes within the existing national disease surveillance system that can be feasibly integrated. However, it must be recognized that a universal fully integrated surveillance system will not fit all diseases and likely cannot be achieved. This is partially due to fundamental differences in objectives and methods of surveillance for certain diseases, which may not allow a complete integration. Nonetheless, there are many components of a surveillance system that can be integrated, thereby improving efficiency and optimizing limited resources. The protocol developed and implemented as a field guide in Costa Rica continues to evolve. An important lesson learned is that any approach to iVPD surveillance must be flexible and must be able to respond to local conditions. Accordingly, the field guide continues to be modified and evaluated. Once finalized, this guide will be distributed for use in other countries and regions of the world. Our experience demonstrates that expectations from the start have always been high, but those expectations need to be balanced and adjusted appropriately with the realities of the field. Sustaining the commitment to do so will be a challenge in any country.

Acknowledgements

Brent Burkholder, Umesh Parashar, Cynthia Whitney, and Nancy Messonnier for support in initiating this project. Jon Gentsch, Susan Reef, Paul Rota, Cristiana Toscano for review of the protocol.

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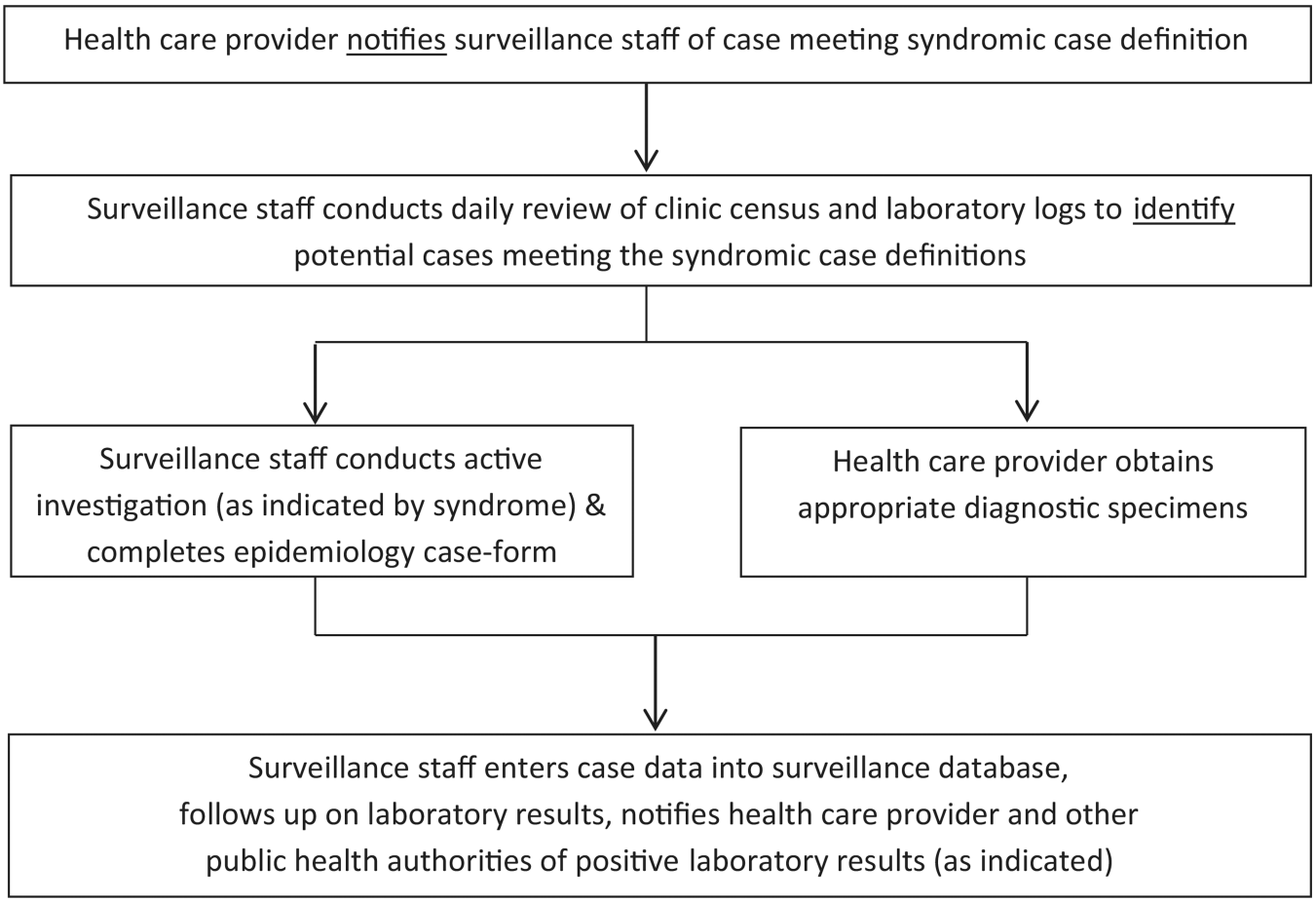

Fig. 1.
Syndromes and diseases under surveillance, age groups, laboratory specimen for collection; clinical surveillance algorithm.

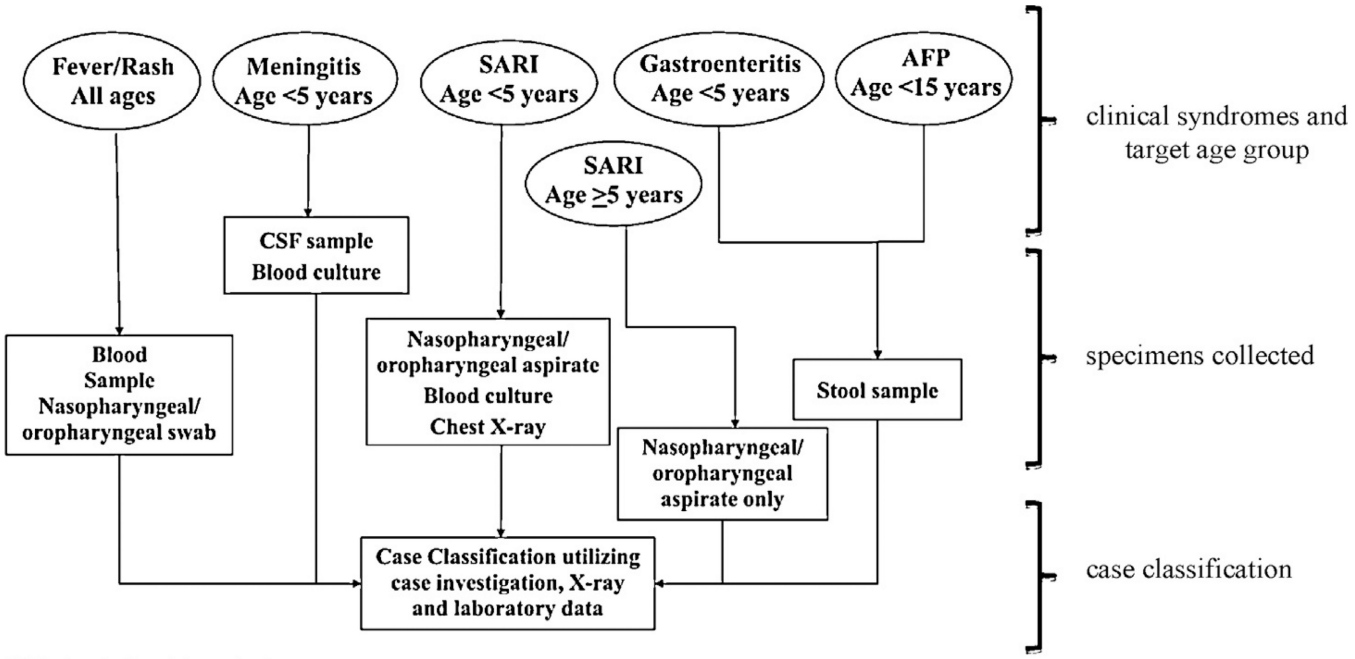

Fig. 2.

Syndromes and age groups targeted for surveillance, samples collected for each syndrome and process of case-classification – integrated vaccine-preventable diseases surveillance.

Table 1

Attributes of disease-specific surveillance systems that could feasibly be integrated with at least one other disease-specific surveillance system.

	Polio	Measles	Rubella	Haemophilus influenza type b	Pneumococcus	Influenza	Rotavirus	Varicella	Pertussis
System of notification									
Case definition	−	+	+	+	+	+	−	+	+
Case detection	+	+	+	+	+	+	+	+	+
Case notification	+	+	+	+	+	+	+	+	+
Case investigation	+	+	+	+	+	+	+	+	+
Data management									
Analysis	+	+	+	+	+	+	+	+	+
Feedback	+	+	+	+	+	+	+	+	+
Case classification[a]	+	+	+	+	+	+	+	+	+
Outbreak response	−	−	−	−	−	−	−	−	−
Laboratory aspects									
Quality control	+	+	+	+	+	+	+	+	+
Training	+	+	+	+	+	+	+	+	+
Specimen processing	−	−	−	+	+	−	−	−	−
Management coordination	+	+	+	+	+	+	+	+	+

+ = amenable to integration, − = not amenable to integration.

Feasibility for integration – whether this surveillance element of the VPD could be combined/integrated with the same element of another VPD.

[a]Case classification dependent on specific laboratory testing for each disease.

Table 2

Proposed integrated surveillance by health care site, syndromes, and diseases.

Location	Syndrome	Diseases/infections
All health care sites (entire population)	Acute flaccid paralysis	Polio
	Fever/rash	Measles, rubella
Sentinel clinic(s)	Moderate acute gastroenteritis[a]	Rotavirus
	Fever/rash (non-measles/rubella)	Varicella
	Influenza-like illness	Influenza, pertussis
Sentinel hospital	Severe gastroenteritis[b]	Rotavirus
	Meningitis	*Haemophilus influenzae*, pneumococcus, meningococcus
	Severe acute respiratory illness	*Haemophilus influenzae*, pneumococcus, influenza, pertussis

[a] Moderate gastroenteritis – not requiring hospitalization; may be considered if resources are available and countries would like more information on baseline and rotavirus vaccine impact on moderate gastroenteritis caused by rotavirus.

[b] Severe gastroenteritis – requiring hospitalization.